Project Report

on

PLC Based Temperature and On-Off Control of Dual Motor System

Project report submitted for partial fulfilment of the internship entitled

'Industrial Automation and Project Based Learning'

Provided by SURE-TRUST

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Year: 2024

Acknowledgement

We would like to extend our heartfelt gratitude to SURE-TRUST and Radha Kumari Mam for providing us with the opportunity to undertake this internship and project. Their support and encouragement have been invaluable throughout this journey, enabling us to gain practical experience and deepen our understanding of industrial automation.

We are profoundly grateful to our trainer, Bhevesh Diyodara Sir, for allowing us to carry out this project under his expert guidance. His unwavering support, inspiration, and insightful feedback throughout the entire internship and project have been instrumental in our success. His mentorship has not only helped us navigate the challenges of this project but also inspired us to strive for excellence in our work.

Additionally, we wish to thank our college professors, Dr. Madhuchanda Mitra, Dr. Chanchal Dey, Dr. Ujjwal Mondal, and Dr. Sourav Paul, for their continuous support. They generously provided us with access to the laboratory facilities, which was crucial for conducting our experiments and implementing our project. Their occasional guidance and expert advice significantly contributed to our understanding and the successful completion of our project. We are deeply appreciative of their willingness to support our educational and professional growth.

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ABSTRACT

In this project, we developed a dual motor system commonly employed in hydraulic systems in industrial settings. Both motors are operated via a Programmable Logic Controller (PLC), which interfaces with push buttons for manual control. Additionally, the PLC is programmed to continuously monitor the temperature of the secondary motor. Upon detecting that the temperature has reached a predetermined threshold, the PLC initiates specific actions to address the situation. This could involve shutting down the motor to prevent overheating, activating cooling mechanisms, or alerting maintenance personnel to take necessary precautions. This comprehensive control and monitoring system ensures optimal performance and safety in industrial applications.

Chapter 1

Introduction

1.1 Motivation:

As an Instrumentation Engineering graduate and prospective industrial trainee, mastering industrial automation is crucial for our professional development in modern industries. Industrial automation encompasses a wide array of systems and technologies, including pneumatic systems, hydraulic systems, Distributed Control Systems (DCS), Programmable Logic Controllers (PLC), and Human-Machine Interfaces (HMI), among others. Each of these components plays a vital role in enhancing operational efficiency, safety, and precision in industrial environments.

In our internship focused on industrial automation, we have chosen to concentrate specifically on hydraulic systems and PLC-based control systems. This focus allows us to delve deeply into the intricacies of these critical components, which are widely used in various industrial applications. Hydraulic systems are known for their ability to generate significant force from relatively compact components, making them indispensable in heavy machinery and equipment. PLCs, on the other hand, are central to automation, providing the necessary control and flexibility to manage complex industrial processes.

Another key aspect of industrial automation is the measurement and control of various parameters, which ensures the optimal performance of systems and processes. Among these parameters, temperature control is particularly important as it can significantly impact the efficiency and safety of industrial operations. To address this, we have decided to incorporate temperature controllers into our project. These controllers will enable us to maintain precise temperature conditions, thereby preventing potential equipment damage and ensuring consistent product quality.

By undertaking this project, we aim to gain practical, hands-on experience in the field of industrial automation. We will not only enhance our understanding of hydraulic systems and PLCs but also develop skills in parameter measurement and control. This comprehensive approach will prepare us for future challenges in the industry, equipping us with the expertise needed to excel in our careers.

Ultimately, this project serves as a foundational step in our journey toward becoming proficient in industrial automation. It will provide us with valuable insights and practical knowledge, fostering a deeper appreciation for the complexities and innovations that drive modern industrial processes. Through this experience, we hope to contribute effectively to the advancement of industrial automation in our future roles.

1.2 Aim of project:

In this project, we developed a dual motor system commonly employed in industrial settings. Both motors are operated via a Programmable Logic Controller (PLC), which interfaces with push buttons for manual control. Additionally, the PLC is programmed to continuously monitor the temperature of the secondary motor. Upon detecting that the temperature has reached a predetermined threshold, the PLC initiates specific actions to address the situation. This could involve shutting down the motor to prevent overheating, activating cooling mechanisms, or alerting maintenance personnel to take necessary precautions. This comprehensive control and monitoring system ensures optimal performance and safety in industrial applications.

1.3 Plan of work:

This project is divided into two main units. The first unit involves controlling a dual motor system using a Programmable Logic Controller (PLC). To achieve this, we constructed the two motor system and implemented push buttons to turn these motors on and off. These push buttons serve as inputs to the PLC, allowing us to control and synchronize the motors as required.

The second unit focuses on temperature control. In this part, we utilized a temperature controller to monitor the temperature of the secondary motor. When the temperature reaches a predetermined threshold, the controller sends a signal to the PLC. The PLC is programmed to activate an alarm system if the temperature switch is triggered, ensuring that any overheating issues are promptly addressed.

1.4 Components and Cost Estimation:

The components used in this project are-

Components	Units	Cost
PLC	1	5500
12V Motors	2	300
Push button	4	50
Temperature controller with sensor(STC-1000)	1	300
Motor driver(L298N)	1	100
Jumper Wires	20 pc	40
Red LED	1	10
Total cost		6300

Pic-1.1: Picture of whole setup

Chapter 2

Hydraulic Systems

Hydraulic systems are indispensable across a wide range of industrial applications due to their ability to deliver high power and precise control. Their robust and reliable nature makes them ideal for use in environments that demand heavy lifting, precise movements, and consistent performance. These systems are predominantly employed in industries that involve heavy lifting or require the generation of high force or pressure. They are essential in sectors such as metal industries, heavy machinery, mining, and automotive industries. Hydraulic systems are favoured for their efficiency and reliability in handling demanding tasks, providing the necessary power and control for operations that involve substantial loads and high pressure.

2.1 Overview of Hydraulic Systems:

At the heart of a hydraulic system is hydraulic fluid, which is stored in a reservoir and circulated throughout the system by a pump. This fluid is essential for transmitting power within the system. In many hydraulic setups, a second pump is used to maintain the required pressure. The operation of these pumps is critical for the system's functionality. The first pump's role is to feed hydraulic fluid to the second pump. The second pump then ensures that the system operates at the necessary pressure levels to perform various tasks efficiently.

2.2 Project Prototype: Electro-Hydraulic System:

In our project, we aimed to create a prototype of an electro-hydraulic system to simulate the functioning of a typical hydraulic system. To represent the hydraulic setup, we used two motors, each symbolizing one of the pumps. These motors are controlled in a synchronized manner to emulate the precise functionality required in real-world hydraulic systems.

2.3 Synchronization of Motors:

The synchronization of the motors in our project is a critical aspect of accurately representing a functional hydraulic system. In a hydraulic system, the first pump must be activated before the second one. This sequence is vital because the first pump must feed hydraulic fluid into the system before the second pump can maintain the necessary pressure. Therefore, we programmed our motors to follow this exact sequence.

1. **Activation Sequence**: The first motor, representing the first pump, is turned on to start circulating hydraulic fluid into the system.
2. **Conditional Operation**: Only after the first motor is running and has fed sufficient hydraulic fluid into the system, the second motor, representing the second pump, can be turned on.
3. **Automatic Deactivation**: The second motor is programmed to automatically turn off if the first motor is turned off. This ensures that the second pump (motor) only operates when the first pump (motor) is actively feeding fluid into the system.

The correct sequence of operations in hydraulic systems is crucial for their efficiency and safety. Activating the second pump without sufficient hydraulic fluid can lead to operational failures and potential damage to the system. By synchronizing the motors in our project, we ensure that the prototype accurately reflects these critical operational protocols.

Chapter 3

Programmable Logic Controller(PLC)

Programmable Logic Controllers (PLCs) are among the most powerful tools in industrial automation, widely utilized across a spectrum of industries, from small-scale operations to large-scale manufacturing plants. PLCs are designed to control a variety of processes, whether small or medium in scope, providing precise and reliable automation solutions. One of the key advantages of PLCs over other industrial controllers is their minimal scan time, which allows them to execute control programs rapidly and efficiently. This quick response time makes PLCs ideal for applications requiring high-speed operations and real-time control, such as safety systems and emergency shutdown procedures.

PLCs are manufactured by numerous leading companies, each offering a range of models tailored to different industrial needs. Notable manufacturers include Allen-Bradley, Siemens, Delta, Yokogawa, Mitsubishi, Schneider Electric, Emerson, IDEC, ABB, and Omron. These companies provide PLCs with varying configurations to suit diverse applications, with differences in the number of input and output points, processing capabilities, and the type of microcontroller used. The wide selection ensures that businesses can find PLCs that match their specific requirements, whether they need a basic controller for simple tasks or a more advanced system for complex processes.

In addition to their technical capabilities, PLCs are known for their durability and reliability, making them suitable for harsh industrial environments. They are built to withstand extreme conditions such as high temperatures, dust, moisture, and vibration, ensuring uninterrupted performance. The programmability of PLCs using languages like ladder logic, structured text, and function block diagrams provides flexibility in designing control strategies. This adaptability, combined with their robust nature and quick processing speed, underscores why PLCs are a cornerstone in modern industrial automation, offering enhanced productivity, improved safety, and operational efficiency across various sectors.

3.1 Allan-Bradley 1761 MicroLogix 1000:

In our project, we utilized the Allen-Bradley 1761 MicroLogix 1000 PLC, a compact and cost-effective solution designed for small-scale industrial automation. This particular PLC model features 20 input ports and 12 output ports, making it suitable for a variety of control tasks. To enhance its functionality, we integrated the PLC into a custom-built shoebox containing an additional set of 20 input ports and 12 output ports, all directly connected to the PLC.

Pic-3.1: Allan-Bradley 1761 MicroLogix 1000 PLC

The shoebox is configured to streamline input and output management. Of the 20 input ports in the shoebox, 10 are designated for switches and 10 for push buttons, providing a versatile interface for user interactions. Although switches and push buttons are already installed on the shoebox, the design allows for external inputs to be connected as well. On the output side, the shoebox's 12 output ports are also directly connected to the PLC, and an additional 24V power supply is provided for external uses. This setup ensures that the Allen-Bradley 1761 MicroLogix 1000 PLC, in combination with the shoebox, offers a robust and flexible control system for small-scale industrial automation. Below is an image of the Allen-Bradley 1761 MicroLogix 1000 PLC along with the shoebox-

Pic-3.2: PLC along with shoe board

RSLogix 1000-

In our project, RSLogix 1000 software was instrumental in programming the Allen-Bradley 1761 MicroLogix 1000 PLC. RSLogix 1000 stands out for its user-friendly interface that supports ladder logic programming, making it exceptionally suitable for developing and refining control strategies. This software facilitates seamless setup of input and output configurations, allowing for precise customization of control parameters. Moreover, RSLogix 1000 enables thorough testing of control logic, ensuring robust system performance before deployment.

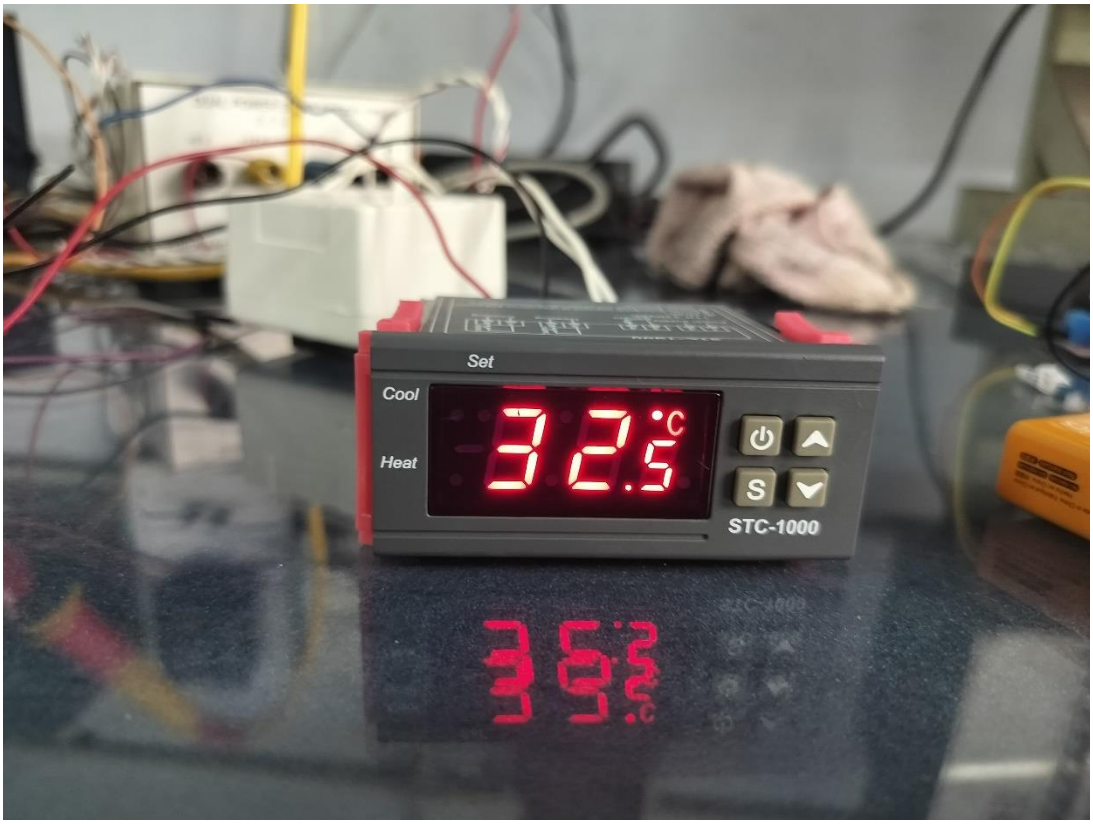
The software's monitoring capabilities play a crucial role in overseeing the operational dynamics of our industrial automation project. RSLogix 1000 provides comprehensive insights into real-time system behaviour, enhancing our ability to fine-tune and optimize the PLC's functionality. By leveraging this integrated hardware-software solution, we ensure an efficient and structured approach to managing and enhancing industrial automation processes, meeting project objectives effectively.

Chapter 4:

Temperature Controller

In our project, we implemented a safety system for monitoring motor temperatures using the STC-1000 temperature controller. This device plays a crucial role with its dual capabilities for both sensing and controlling temperature. Utilizing a standard NTC thermistor sensor, the STC-1000 accurately measures temperatures, crucially detecting when temperatures exceed predefined thresholds. The sensor transmits temperature data to the microcontroller embedded within the STC-1000, which then evaluates whether the temperature falls within acceptable limits or requires intervention.

With its ability to handle both heating and cooling functions, the STC-1000 can autonomously activate or deactivate connected devices based on user-defined settings. It operates effectively across a wide temperature range from -50°C to 99°C, ensuring robust performance in diverse industrial environments. The STC-1000's versatility, affordability, and wide availability made it an ideal choice for our project's safety system, offering reliable temperature monitoring and control capabilities essential for safeguarding motor operations in industrial settings.



Pic-4.1: STC-1000 temperature controller

Chapter 5:

Project Details

In this project, we programmed a PLC to control two motors in a synchronized manner, ensuring that the first motor must always be turned on before the second motor. Both motors are operated using push buttons, but the system is designed so that the second motor can only be activated if the first motor is already running. If the first motor is turned off while both motors are operating, the second motor will automatically shut down as well. This sequential control ensures proper operation and prevents the second motor from running independently.

Additionally, we integrated a temperature controller to monitor the motors' temperature. If the temperature exceeds the predefined limit, both motors are immediately shut off, and an alarm system is triggered. The alarm will remain active until the temperature drops back to the reset point, at which point it will automatically turn off. The control logic for these operations was implemented using ladder logic, providing a reliable and efficient control system for motor synchronization and temperature-based safety measures.

5.1 Inputs and Outputs:

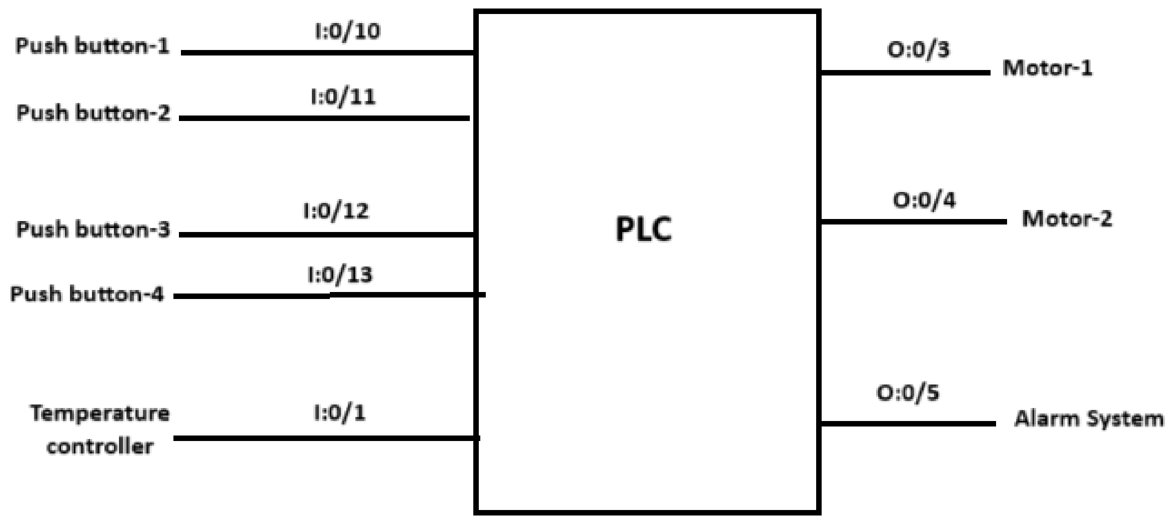
In this project, we have configured a total of five inputs to the PLC and three outputs emanating from it, creating a comprehensive control and safety system for the motors. Among the inputs, two push buttons are designated to control each of the motors independently. The first push button is responsible for turning the first motor on and off, while the second push button manages the same for the second motor. This setup allows for precise manual control over the activation of the motors, ensuring they operate in the desired sequence.

In addition to the push buttons, a temperature switch is integrated as a crucial safety measure. This temperature switch continuously monitors the thermal conditions of the motors. If the temperature exceeds a predefined safety threshold, it triggers an input to the PLC, signalling that the system needs to initiate protective actions. This ensures that the motors do not overheat, thus preventing potential damage or hazardous situations.

On the output side, the PLC controls three devices. Two outputs are allocated for managing the motors, corresponding to the inputs from the push buttons. These outputs directly influence the operational state of the motors, enabling or disabling them based on the received commands and the programmed logic. The third output is connected to an alarm system. In the event that the temperature switch detects an unsafe temperature level, this output activates the alarm, alerting operators to the issue. The alarm system remains active until the temperature falls back to a safe level, at which point the alarm is automatically reset.

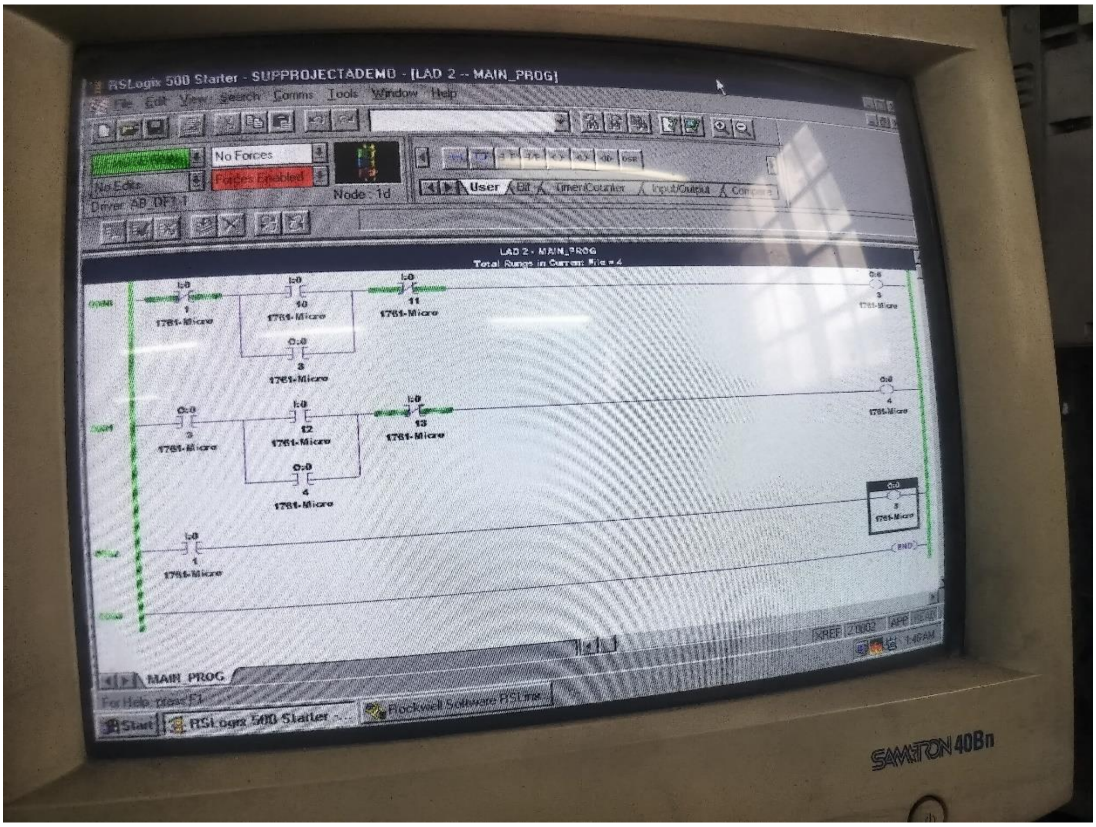
This comprehensive arrangement of inputs and outputs ensures that the PLC effectively manages the motor operations while providing essential safety controls. The integration of manual control through push buttons and automated safety responses via the temperature switch and alarm system creates a robust and reliable industrial automation setup.

Input Indication	Significance	Output Indication	Significance
I:0/1	Temperature controller	O:0/3	For controlling Motor-1
I:0/10	Push button-1 for turning on the first motor	O:0/4	For controlling Motor-2
I:0/11	Push button-2 for turning off the first motor	O:0/5	For controlling alarm system.
I:0/12	Push button-3 for turning on the second motor		
I:0/13	Push button-4 for turning off the second motor		



Pic-5.1: Connection of PLC

5.2 Ladder Logic:



Pic-5.1: Ladder logic for our project

This the ladder logic of our program .In this ladder logic there are total three rungs.

Rung-1:

First rung signifies the controlling the Motor-1. Here are three inputs I:0/1 , I:0/10, I:0/11 and one output O:0/3. The motor will be turned on only if the temperature switch is off and the Push button-1 is pushed. If Push button-2 is pushed or temperature switch is on then Motor-1 will turn off.

Rung-2:

Second rung signifies the controlling of Motor-2. Here are three inputs O:0/3, I:0/12, I:0/13 and one output O:0/4. The Motor-2 will be turned on only if Motor-1 is on and Push button-3 is pushed. If Motor-1 is off or Push button-4 is pushed then Motor-2 will turned off.

Rung-3:

Third rung signifies the alarming system. It contains only one input I:0/1 and one output O:0/5. The alarm system will turn on when temperature switch is on and it will be turned off when the temperature switch is off. Here the set temperature is given as 32.5°c and reset point as 0.3°c i.e. 32.2°c. So temperature switch will be on when temperature reached 32.5°c and will turn off again when temperature returns to 32.2°c.

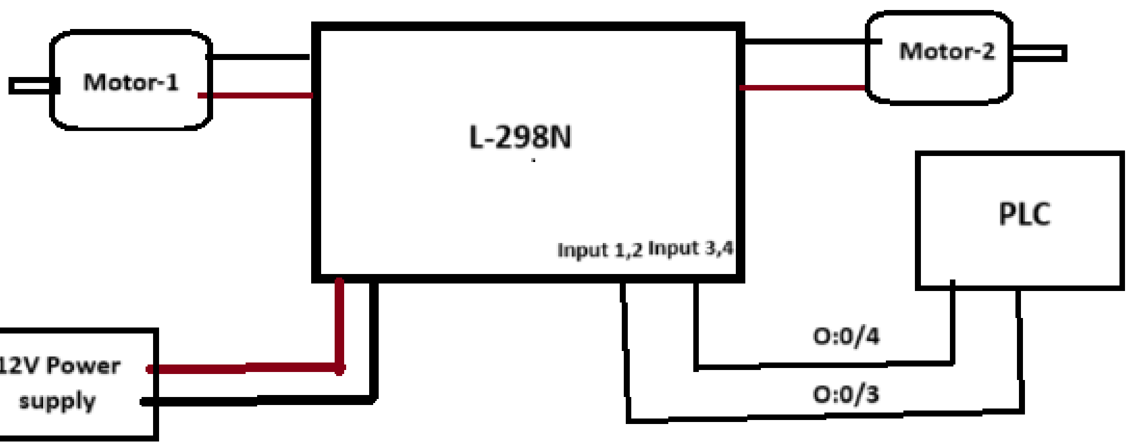
5.3 Motor control and Alarm System:

To control the motors in our project, we have utilized the L-298N motor driver, which is specifically designed to handle dual motor control simultaneously. The L-298N motor driver is equipped with two sets of inputs and outputs, allowing it to independently manage two motors. It operates on a 12V DC power supply, making it suitable for our application requirements.

The connection setup is as follows: Inputs 1 and 2 of the L-298N motor driver are connected to the outputs of the PLC at O:0/3. This configuration allows the PLC to send control signals to the motor driver, thereby managing the operation of Motor-1. Similarly, Inputs 3 and 4 of the motor driver are connected to another output of the PLC at O:0/4, enabling control over Motor-2. The motor driver's outputs are then directly connected to the respective motors, with Output 1 and 2 linked to Motor-1 and Output 3 and 4 linked to Motor-2.

This setup ensures that the PLC can effectively control both motors through the L-298N motor driver. When the PLC sends signals to O:0/3, it controls the activation and operation of Motor-1 via the corresponding inputs and outputs of the motor driver. Similarly, signals sent to O:0/4 manage Motor-2. This arrangement allows for precise and synchronized control of both motors, ensuring they operate in tandem according to the logic programmed into the PLC.

By integrating the L-298N motor driver with our PLC and motors, we achieve a reliable and efficient control system. The motor driver's capability to handle dual motor operations concurrently, combined with the PLC's programmable logic, ensures smooth and coordinated motor performance, which is critical for the overall functionality and safety of our project.



Pic-5.2: Connection diagram of motor driver

L298N pin	Connected Device
+ 12V DC	12V DC power supply
Ground	Ground
Input-1,2	PLC output O:0/3
Input-3,4	PLC output O:0/4
Output- 1,2	Motor-1
Output-3,4	Motor-2

For our alarming system, we have employed an LED indicator, which is connected to the PLC's output at O:0/5. This LED serves as a visual alert mechanism to signal when the temperature of the motor exceeds the predetermined threshold set by the temperature switch.

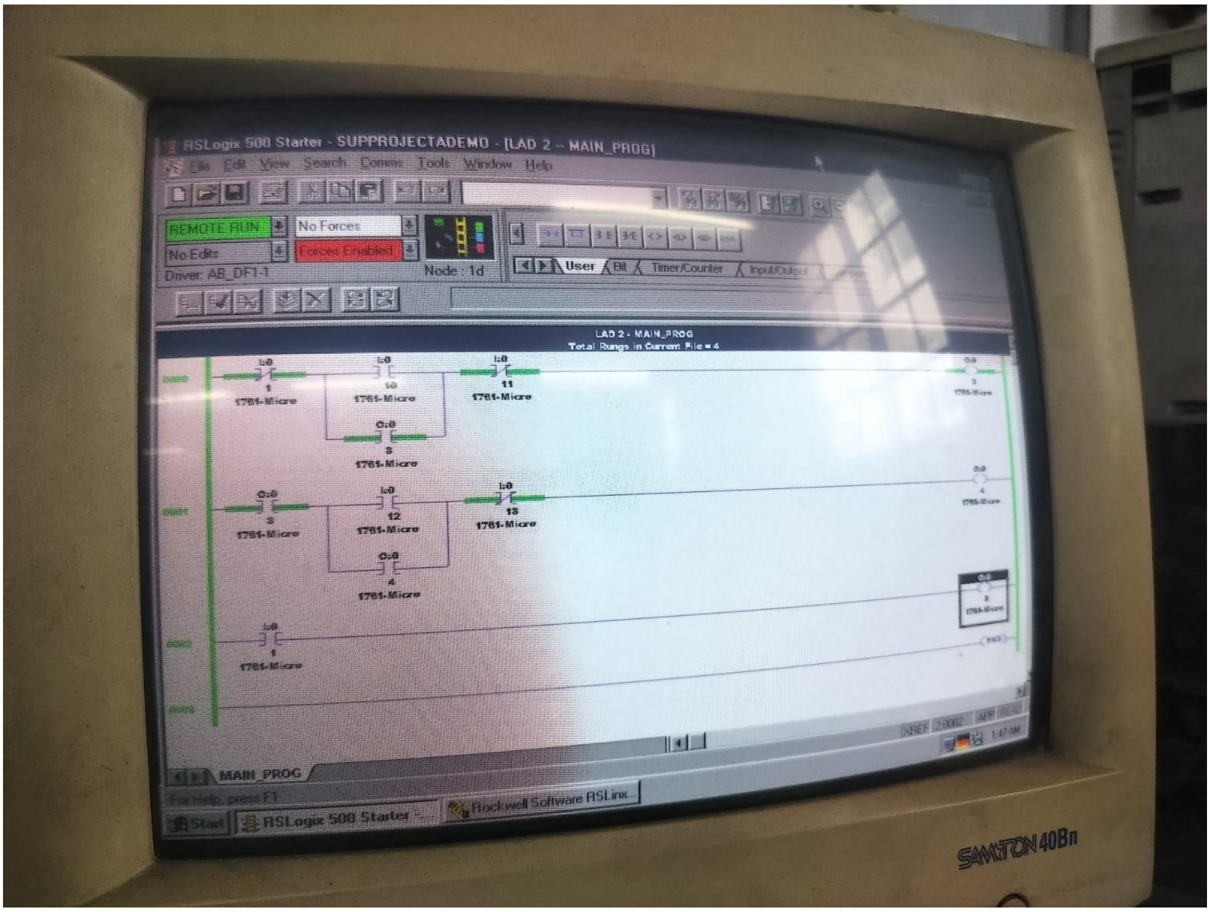
The operational logic of the alarming system is straightforward yet effective. When the temperature switch detects that the motor's temperature has reached or surpassed the critical limit, it sends a signal to the PLC. Upon receiving this input, the PLC activates its output at O:0/5, which in turn powers the LED, causing it to light up. This immediate visual cue alerts operators to the potential overheating issue, prompting them to take necessary action to mitigate any risks.

Conversely, when the temperature falls back below the critical threshold and the temperature switch is deactivated, the signal to the PLC changes. The PLC then responds by deactivating the output at O:0/5, causing the LED to turn off. This indicates that the motor's temperature has returned to a safe level and the alarming condition has been resolved.

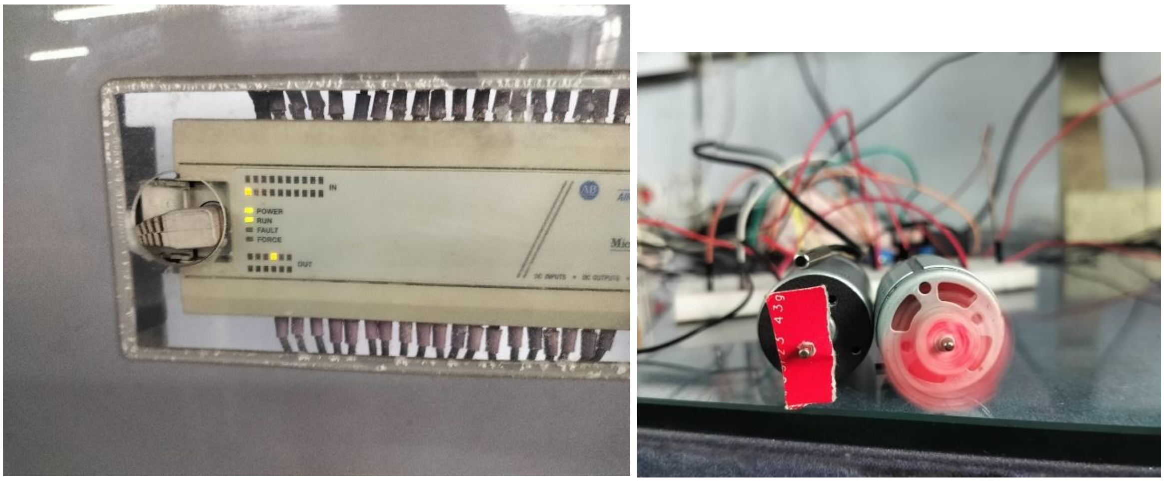
By integrating this LED alarm system, we ensure that any temperature-related issues are promptly and clearly communicated to the operators. The use of the LED as a visual indicator provides an intuitive and easily recognizable alert mechanism, enhancing the overall safety and responsiveness of the motor control system. This setup underscores the importance of real-time monitoring and immediate feedback in maintaining safe operational conditions in industrial environments.

Chapter 6:

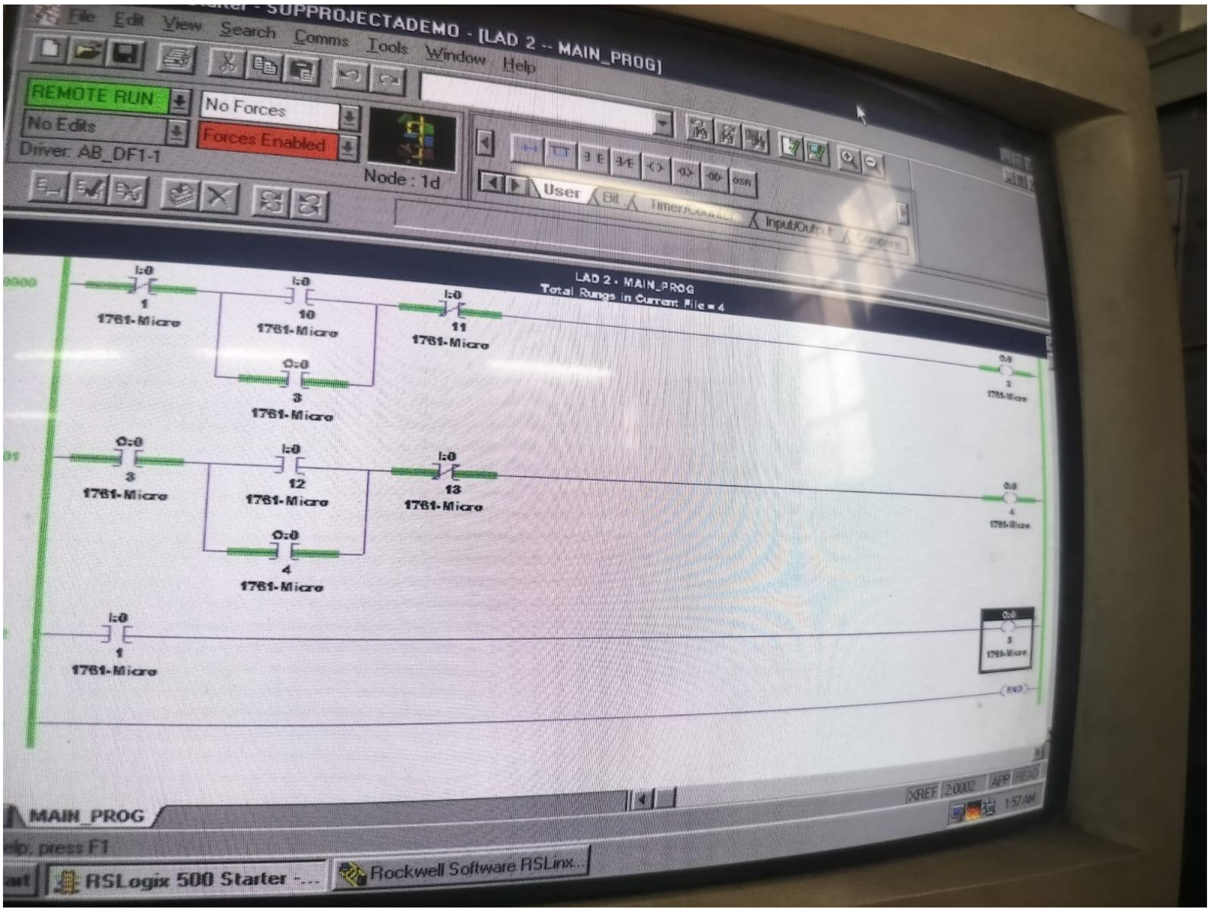
Result



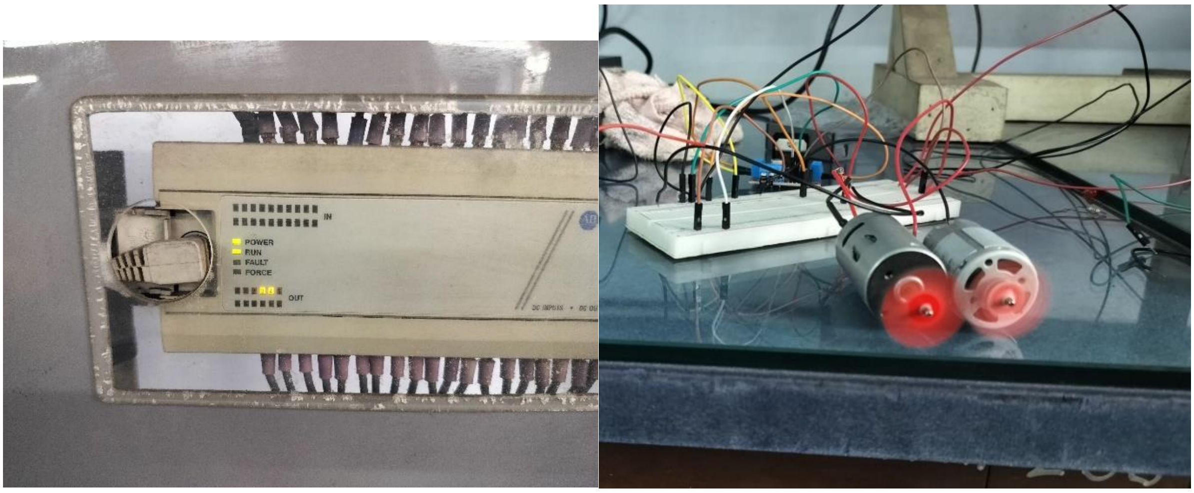
Pic-6.1: Simulation when Motor-1 ON



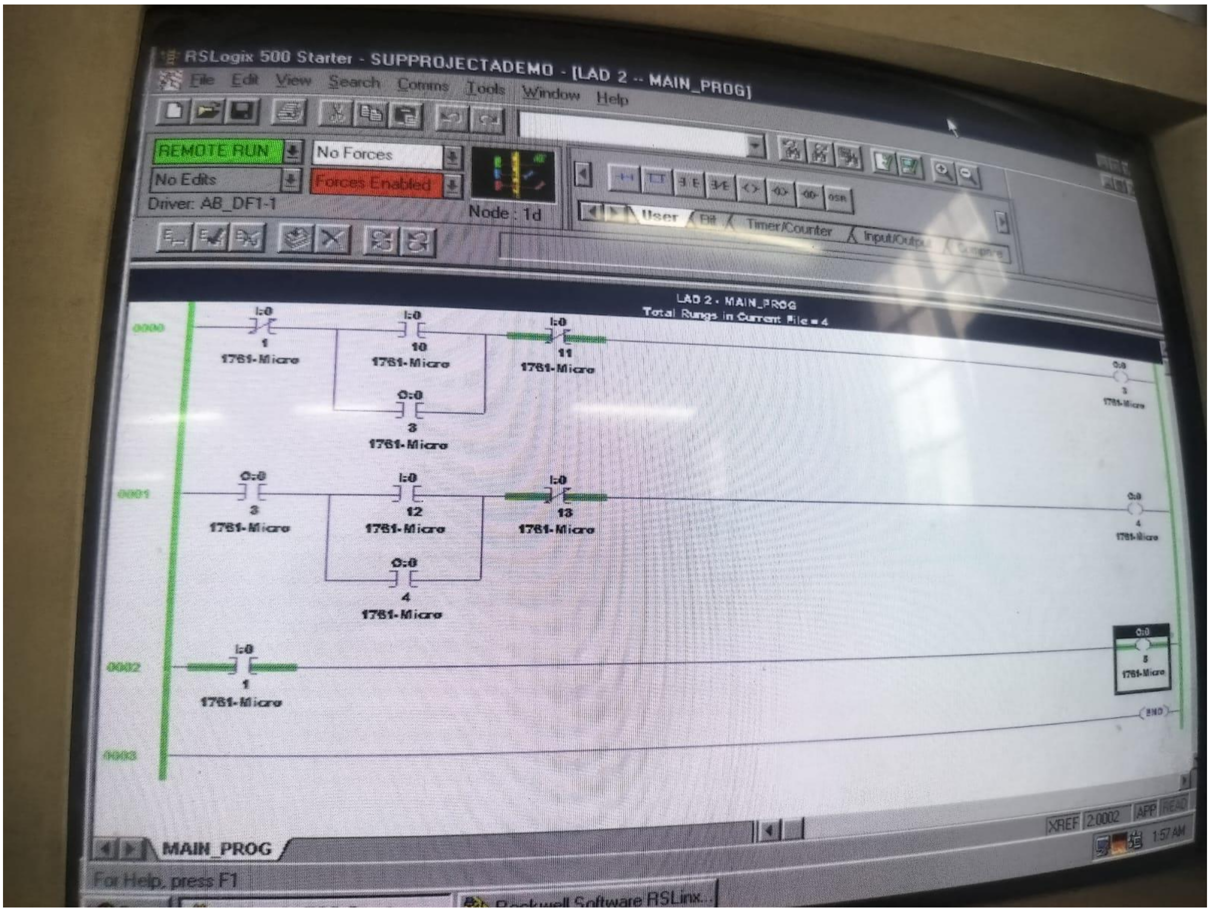
Pic-6.2: Output when Motor-1 is ON



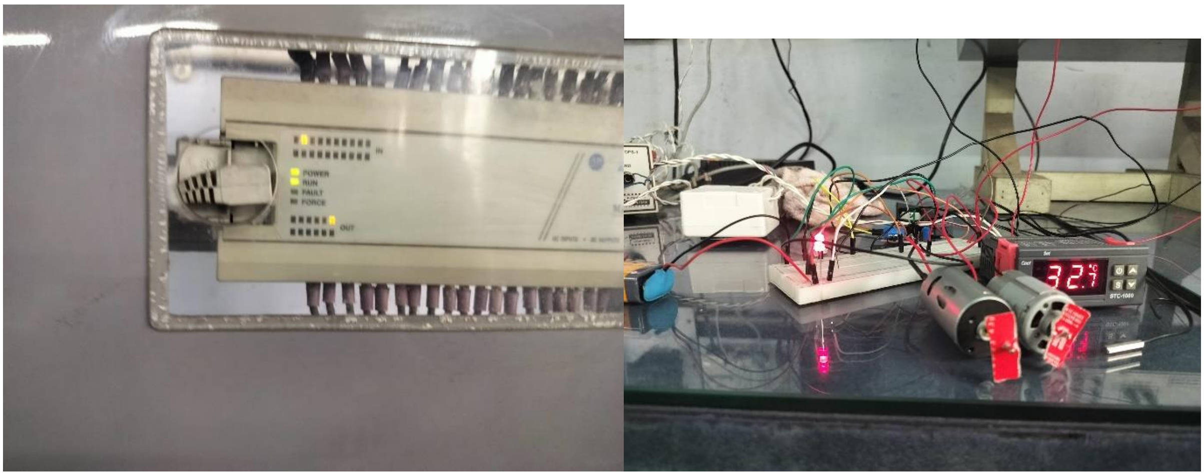
Pic-6.3: Simulation when Motor-2 is ON



Pic-6.4: Output when Motor-2 is ON



Pic-6.5: Simulation when alarm system is ON



Pic-6.6: Output when alarm system is ON

Chapter 7:

Conclusion

In conclusion, our project demonstrates the successful integration and synchronization of a dual motor control system using a PLC, enhanced by a robust safety mechanism through the STC-1000 temperature controller. By employing push buttons for manual control and implementing a temperature-based automatic shutdown feature, we created a reliable and efficient motor management system. The utilization of the L-298N motor driver ensured precise and coordinated motor operations, while the LED alarm system provided immediate visual feedback on critical temperature conditions.

The core of our system revolves around the PLC, which controls the operation of two motors in a synchronized manner, ensuring that the first motor is always activated before the second. This design prevents potential operational errors and guarantees the system's reliability. The STC-1000 temperature controller continuously monitors the motor temperature, and if the threshold is exceeded, it signals the PLC to shut down both motors, thereby preventing overheating and potential damage. The LED alarm, connected to the PLC output, offers clear visual alerts when the motors exceed safe temperature limits.

Overall, this project has provided valuable insights into the practical applications of PLC programming and industrial automation. We have learned the importance of integrating manual and automated controls to achieve a balanced, safe, and efficient system. The hands-on experience with temperature control, motor driver integration, and alarm systems has enriched our understanding of maintaining operational safety and reliability in industrial settings. This project serves as a solid foundation for future endeavours in the field of instrumentation engineering and industrial automation.

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